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DIPARTIMENTO DI TECNICA E GESTIONE DEI SISTEMI INDUSTRIALI

SUSTAINABLE MOBILITY

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Abstract

This thesis presents a comprehensive study on developing a machine learning model to predict mobility patterns in various weather conditions and group structures. The primary focus of this project is to assess the effectiveness of machine learning models in forecasting mobility behavior, considering different weather scenarios, social contexts, and route characteristics. Additionally, the research aims to identify the key factors influencing mobility behavior and explore the potential application of machine learning models in personalized mobility prediction and sustainable transportation planning.

To achieve these objectives, a range of machine learning models will be evaluated for their accuracy and precision in forecasting mobility patterns. The research will investigate how different models perform in predicting mobility behavior under varying weather conditions and social contexts. Moreover, an in-depth analysis will be conducted to identify the factors that significantly impact the accuracy of these models.

By examining the accuracy and precision of various machine learning models, this research will provide valuable insights into their effectiveness in mobility forecasting. Furthermore, it will uncover the factors that play a crucial role in influencing the accuracy of these models. The findings of this study will contribute to the advancement of machine learning applications in transportation planning and assist in developing personalized mobility prediction systems for sustainable transportation.

Keywords: machine learning, mobility patterns, weather conditions, group structures, accuracy, precision, personalized mobility prediction, sustainable transportation planning

Astratto

Questa tesi presenta uno studio approfondito per lo sviluppo di un modello di apprendimento automatico per prevedere i modelli di mobilità in diverse condizioni meteorologiche e strutture di gruppo. Il focus principale di questo progetto è

valutare l'efficacia dei modelli di apprendimento automatico nella previsione del comportamento di mobilità, considerando diversi scenari meteorologici, contesti sociali e caratteristiche del percorso. Inoltre, la ricerca mira a identificare i fattori che influenzano il comportamento di mobilità ed esplorare la possibilità di utilizzare i modelli di apprendimento automatico per la previsione della mobilità personalizzata e la pianificazione del trasporto sostenibile.

Per raggiungere questi obiettivi, verranno valutati diversi modelli di apprendimento automatico per la loro accuratezza e precisione nella previsione dei modelli di mobilità. La ricerca indagherà su come diversi modelli si comportano nella previsione del comportamento di mobilità in diverse condizioni meteorologiche e contesti sociali. Inoltre, verrà condotta un'analisi approfondita per identificare i fattori che influenzano in modo significativo l'accuratezza di questi modelli.

Attraverso l'esame dell'accuratezza e della precisione dei vari modelli di apprendimento automatico, questa ricerca fornirà preziose intuizioni sulla loro efficacia nella previsione della mobilità. Inoltre, svelerà i fattori che giocano un ruolo cruciale nell'influenzare l'accuratezza di questi modelli. I risultati di questo studio contribuiranno all'avanzamento delle applicazioni di apprendimento automatico nella pianificazione dei trasporti e aiuteranno nello sviluppo di sistemi di previsione della mobilità personalizzata per il trasporto sostenibile.

Parole chiave: apprendimento automatico, modelli di mobilità, condizioni meteorologiche, strutture di gruppo, accuratezza, precisione, previsione della mobilità personalizzata, pianificazione del trasporto sostenibile.

Acknowledgement

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Introduction

With the rapid expansion of cities and the escalating worries regarding the sustainable use of our natural resources, the quest for achieving transportation systems that are not only efficient but also eco-friendly has garnered significant attention and become an urgent global challenge. Sustainable mobility, often referred to as sustainable transportation, aims to develop and implement strategies that promote the efficient movement of people and goods while minimizing negative environmental and social impacts.

Furthermore, machine learning, a field of artificial intelligence, involves the development and application of computational models that can automatically learn and improve from data without explicit programming. By analyzing large and diverse datasets, machine learning algorithms can identify patterns, make predictions, and gain valuable insights that aid decision-making processes. In the context of sustainable mobility, machine learning can provide innovative solutions to optimize transportation systems, improve accessibility, and minimize environmental impact.

Optimizing transportation systems through machine learning involves the application of data analytics to enhance operational efficiency, reduce congestion, and improve the overall performance of transportation networks. By processing large volumes of data collected from sources such as traffic sensors, GPS devices, and social media platforms, machine learning algorithms can generate real-time traffic predictions, optimize routing, and dynamically adapt transportation services. These advancements lead to improved travel experiences, reduced travel times, and more efficient allocation of resources.

Accessibility is a key aspect of sustainable mobility, aiming to ensure that transportation services are available and equitable for all individuals, regardless of their physical abilities, income levels, or geographic location. Machine learning algorithms can help address accessibility challenges by analyzing data on travel demand, demographics, and infrastructure characteristics. This enables the identification of underserved areas, optimization of transit routes, and the design of transportation services that cater to the needs of diverse populations.

Environmental sustainability is another critical dimension of sustainable mobility. Transportation accounts for a significant portion of global greenhouse gas emissions and is a major contributor to air pollution. Machine learning can play a crucial role in minimizing the environmental impact of transportation by developing predictive models that estimate emissions, optimize energy consumption, and facilitate the integration of clean and renewable energy sources. Additionally, machine learning techniques can aid in the design of eco-routing algorithms, which suggest the most environmentally friendly travel routes based on real-time data.

In summary, the combination of machine learning and sustainable mobility presents a promising framework to address the complex challenges faced by transportation systems. By harnessing the power of machine learning algorithms, transportation stakeholders can optimize operations, improve accessibility, and mitigate environmental impact. As the demand for sustainable and efficient mobility solutions continues to grow, machine learning can provide valuable insights and tools to shape the future of transportation, leading to more sustainable, accessible, and environmentally friendly mobility systems.

1.1 Motivation and Problem Statement

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[Jurgens:2000, Jurgens:1995, Miede:2011, Kohm:2011, Apple:keynote:2010, Apple:numbers:2010, Apple:pages:2010]

1.2 Results

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1.2.1 Some References

[WEB:GNU:GPL:2010, WEB:Miede:2011] And after the second paragraph follows the third paragraph. Hello, here is some text without a meaning. This text should

show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Methodology

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```
1 #!/usr/bin/env python
2 print "Hello World"
```

Listing 1.1: This simple helloworld.py file prints Hello World.

Strategy 2 This is the second paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

```
1  #!/usr/bin/env python
2  def bubble_sort(list):
3      for num in range(len(list)-1,0,-1):
4          for i in range(num):
5              if list[i]>list[i+1]:
6                  tmp = list[i]
7                  list[i] = list[i+1]
8                  list[i+1] = tmp
9
10 alist = [34,67,2,4,65,16,17,95,20,31]
11 bubble_sort(list)
12 print(list)
```

Listing 1.2: This is a bubble sort function.

1.3 Thesis Structure

Chapter 2

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Chapter 3

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Chapter 4

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Chapter 5

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Related Work

“ *A picture is worth a thousand words. An interface is worth a thousand pictures.*

— **Ben Shneiderman**
(Professor for Computer Science)

And after the second paragraph follows the third paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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```
1 public class HelloWorld {  
2     public static void main ( String[] args ) {  
3         // Output Hello World!  
4         System.out.println( "Hello World!" );  
5     }  
6 }
```

Listing 2.1: A simple Hellow World example in Java.

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

2.1 Related Work Section 1

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2.2 Related Work Section 2

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2.4 Conclusion

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System

” *Innovation distinguishes between a leader and a follower.*

— **Steve Jobs**
(CEO Apple Inc.)

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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3.1 System Section 1

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Fig. 3.1.: Figure example: (a) example part one, (c) example part two; (c) example part three

After this fourth paragraph, we start a new paragraph sequence. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

3.2 System Section 2

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Fig. 3.2.: Another Figure example: (a) example part one, (c) example part two; (c) example part three

This is the second paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look.

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3.3 System Section 3

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3.4 Conclusion

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Concepts: This text is here to
test a very long title, to
simulate the line break
behavior, to show that an
extremely long title also works

” *Users do not care about what is inside the box,
as long as the box does what they need done.*

— **Jef Raskin**

about Human Computer Interfaces

This is the second paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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4.1 Concepts Section 1

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4.2 Concepts Section 2 with a very very long title that illustrates how long section titles are handled in the footer

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4.3 Concepts Section 3

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4.4 Conclusion

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Conclusion

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5.1 System Section 1

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5.2 System Section 2

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5.3 Future Work

This is the second paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

And after the second paragraph follows the third paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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After this fourth paragraph, we start a new paragraph sequence. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

A.1 Appendix Section 1

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Alpha	Beta	Gamma
0	1	2
3	4	5

Tab. A.1.: This is a caption text.

A.2 Appendix Section 2

This is the second paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text,

you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Alpha	Beta	Gamma
0	1	2
3	4	5

Tab. A.2.: This is a caption text.

And after the second paragraph follows the third paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Colophon

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Declaration

You can put your declaration here, to declare that you have completed your work solely and only with the help of the references you mentioned.

Padova, September 05, 2023

Nima Karimi

